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Review

# Urban-centric resilience in search of theoretical stabilisation? A phased thematic and conceptual review

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ABSTRACT

Over the last decades '*resilience*' has particularly arisen as an attractive perspective with respect to cities. As cities continue to expand, their susceptibility to uncertainties and new challenges, such as climate change, has increased, rendering '*urban resilience*' an increasingly favoured concept in the realm of Urban Development, Planning and Management (UDPM).

Despite recent reviews, an updated analysis of the concept is required to understand whether there is in fact scientific evidence to support the expansion and favouring of '*urban resilience*' in UDPM. The need to understand how the concept evolved is further emphasised by the need to perceive how the distinct sciences have contributed to its development, and which were the focuses and conceptual underpinnings of such evolution. Thus, the objective of this paper is to provide a broader review of the multidimensional concept of '*urban resilience*', while understanding how distinct research fields have contributed to its inception and expansion, and how distinct conceptualisations of resilience have influenced its evolution.

Supported by a bibliometric analysis of urban-centric publications, this paper highlights the recent extensive growth and expanding application of '*urban resilience*' to distinct research fields, as well as an apparent theoretical stabilisation of the concept, which reemphasises the idea of a three-dimensional conceptual resilience perspective in scientific literature: (1) 'engineering', (2) 'ecological', and (3) 'social-ecological resilience'. Consequently, this research emphasises that, if the related conceptual underpinnings are clear, '*urban resilience*' can potentially serve as an '*integrative metaphor*', adapted by diverse stakeholders, to reinforce UDPM initiatives.

## 1. Introduction

Decades of theoretical research in the empiric and formal sciences have contributed to a better understanding of the dynamics of single-equilibrium, multiple-equilibria, and non-equilibrium behaviours. This knowledge has subsidised the establishment of '*resilience theory*' (Holling et al., 2001; Redman and Kinzig, 2003; Curtin and Parker, 2014) as a formal approach to understanding how systems respond to, persist under, and adapt to disturbances. Although early literature was conceptual and focused on developing a baseline for '*resilience theory*' (Bhamra et al., 2011, p. 5380), over time a broad range of practical studies were developed (Redman and Kinzig, 2003; Shaw, 2012; Béné et al., 2014). Resilience-focused research grew from its original formulation in Engineering, to its application in Ecology (Mcaslan, 2010; Bhamra et al., 2011; Martin-Breen and Anderies, 2011), and to its applied development in urban-centric research (Cartalis, 2014; Hassler and Kohler, 2014a).

The seminal work of Holling and colleagues (Holling and Goldberg, 1971; Holling, 1973, 1986; 1996, 2001; Folke et al., 2002) formed the foundation for the development of resilience studies and reinterpretations (Mcaslan, 2010; Bhamra et al., 2011; Martin-Breen and Anderies, 2011). Their work, along with continuous processes of social, economic and ecological change (Vale, 2014, p. 192), and increasingly unforeseen disturbances (Walker and Salt, 2006; Hodson and Marvin, 2009; Balaban, 2012), have highlighted the value of resilience research (Redman and Kinzig, 2003; Shaw, 2012; Hassler and Kohler, 2014a). Consequently, resilience has been widely used by academics, practitioners and policy makers (Mcaslan, 2010; Martin-Breen and Anderies, 2011; Hassler and Kohler, 2014a), traversing several research fields (Mcaslan, 2010; Martin-Breen and Anderies, 2011). Resilience has particularly arisen as an attractive perspective with respect to cities (Meerow et al., 2016), especially in the realm of Urban Development,

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Planning and Management (UDPM) (Godschalk, 2003; Beatley and Newman, 2013; Childers et al., 2015).

Contemporary cities have become the nexus of human activities, with more than 50 per cent of the world's population (Girardet, 1999; Brown et al., 2012). As "complex" (see e.g., Alberti and Marzluff, 2004; Ernstson et al., 2010), "*multi-scalar*" (Meerow et al., 2016, p. 45, p. 45), and "adaptive" systems (Wu, 2014, p. 216), urban environments are composed of distinct *"socio-ecological and socio-technical networks"* that encompass a multitude of "*governance, material and energy flows, infrastructure and form, and social-economic dynamics*" (Meerow et al., 2016, p. 45, p. 45), which operate and interact at various scales (see e.g., Gunderson and Holling, 2001; Holling, 2001). Urban environments are now responsible for some of the highest patterns of consumption of resources, and emission of pollutants (Meerow et al., 2016). As cities continue to expand, their susceptibility to uncertainties and new challenges, such as climate change (Leichenko, 2011; Brown et al., 2012), has increased, rendering '*urban resilience*' an increasingly favoured concept (Pickett et al., 2004; Newman et al., 2009b; Wilkinson et al., 2010; Hassler and Kohler, 2014a).

Nevertheless, the contemporary focus of '*urban resilience*' has varied considerably, as it has been characterised by multiple approaches that have often revolved around the abilities of urban environments (1) to absorb disturbances, (2) to recover from shocks, (3) for self-organization, and (3) for adaptation and transformation (see e.g., Davoudi, 2012; Hassler and Kohler, 2014a). Scientists have used the concept of '*urban resilience*' in UDPM to study how urban environments can absorb and recover from disturbances, adapt and evolve upon new scenarios, and self-organise without the influence of external entities (Newman et al., 2009a; Davoudi, 2012; Cartalis, 2014; Hassler and Kohler, 2014a; Meerow et al., 2016). Likewise, the target subject of '*urban resilience*' research has also varied from the study of urban environments as a whole (see e.g., Pickett et al., 2004; Pickett et al., 2014), to the study of their specific components (see e.g., Douglass, 2000; Andersson et al., 2014), rendering '*urban resilience*' a multi-scalar and multi-focused concept (see e.g., Newman et al., 2009a; Cartalis, 2014; Meerow et al., 2016).

In this context, one should raise the question whether there is, in fact, scientific evidence to support the expansion and favouring of '*urban resilience*' in UDPM. Additionally, our understanding of how the distinct sciences have contributed to the development of '*urban resilience*' and influenced its research focuses, should also be reviewed, considering it has been somewhat limited to specific research branches (Hassler and Kohler, 2014a; Meerow et al., 2016), and circumscribed to specific clusters of knowledge (e.g., Cruz et al., 2013; e.g., Meerow and Newell, 2015). Defining resilience has also proven elusive (Mcaslan, 2010; Meerow et al., 2016). Since the early work of Tredgold (1818) and Holling (1971, 1973), for example, the broader concept of '*resilience*' has known several definitions that have underpinned different conceptual and theoretical approaches (Brand and Jax, 2007; Mcaslan, 2010; Martin-Breen and Anderies, 2011), which have influenced the conceptualisation of '*urban resilience*' (Davoudi, 2012; Meerow et al., 2016). Hence, the theoretical and practical application challenge of developing the concept of '*urban resilience*' in UDPM requires a reasonable knowledge of the source domain (resilience), sufficient to enable a pertinent construct of key relational characteristics from within it, and elucidate essential relational features (Chettiparamb, 2006, p. 78).

Understanding the conceptual implications involved in the evolution of '*urban resilience*', emphasising potential theoretical strains, is crucial to improve our understanding of the subject, thus better informing future urban-centric research. The evolution of urban-centric resilience concepts and related trends is therefore a key point that needs further investigation. The overcoming of the limitations emphasised earlier can be summarised through the following questions: (1) how has '*urban resilience*' evolved into a favoured concept in UDPM; (2) in what way have the different research fields contributed to the development of '*urban resilience*'; (3) has urban resilience evolved conceptually to the point of its theoretical stabilisation. The objective of this paper is to analyse the evolutional phases of the multidimensional concept of '*urban resilience*', while understanding how the distinct research fields have contributed to its inception and expansion. Thus, this investigation intends to contribute to the discussion of patterns, and trends in urban-centric resilience research, understanding whether there has been a search for theoretical stabilisation, and how the distinct conceptualisations of resilience ('*engineering*', '*ecological*', and '*socio-ecological resilience*') have influenced this process.

This paper is divided into five main sections. Following this Introduction (1), which presents the theme and objectives, the Methods section (2) explains the methodological approach followed in this research. The following section (3) presents the results of the study of the evolution of urban-centric resilience, comprising the historical, thematic and conceptual analysis of publications retrieved from the Thompson Reuters Web of Science database (WSd). The subsequent section (4) provides the discussion of the results of this research. Finally, the Conclusions section (5) comprises the main inferences and deductions of this investigation.

## 2. Methods

The academic literature on urban-centric resilience was reviewed to (1) trace the evolution of the concept of '*resilience*' in urban-centric research, (2) determine its thematic urban origins and development, and (3) understand its urban focus and (4) highlight the conceptual underpinnings of its development, across studies and research fields. To provide a more holistic perspective of the evolution of '*urban resilience*' this review was based on the bibliometric analysis of a larger sample of publications, in this case the publications retrieved from the Thompson Reuters Web of Science database (WSd). The WSd was selected because it provided one of the most integrated databases available (compiling the publications released by distinct publishers), and one of largest repositories of urban-centric resilience research.

The WSd was first used to identify the literature on urban-centric resilience, i.e., applications of '*resilience*' to the urban realm. The combination of the search terms '*urban', 'resilience*', '*cities',* and '*resilient*' in the *Topic* of publications (*title*, *abstract*, or *keywords*) yielded 4385 results in the WSd (search performed in February 2018). This first search was then refined to include only relevant publications (i.e., to include articles, proceedings papers, reviews, editorial material, book chapters, and books, excluding corrections, reprints, meeting abstracts, letters, news items, retracted publications, and book reviews) yielding a total of 4180 results, which included publications from 1984 up to 2018. Based on these results, seven distinct five-year periods were demarcated from the dates of the firsts publications (1984, 1986), up to the present time (1984–1989, 1989–1993, 1994–1998, 1999–2003, 2004–2008, 2009–2013, 2013–2018).

The 4180 publications retrieved from the WSd were then agglomerated into each of the predefined periods, following their publication year. These period clusters were then analysed to determine (1) how the number of publications released evolved throughout time. Moreover, to determine the (2) thematic evolution of urban-centric resilience research, the publications of each period cluster were divided according to six research fields (see Fig. 1), and 34 major research areas, which in turn summarise the 151 research subfields of the WSd. This division was based on the thematic classification provided by the WSd (Thompson Reuters Web of Science, 2018). The analysis of each subsequent group of publications, per research field and area, allowed the tracing of the thematic evolution, and the determination of the thematic focuses (the research fields and areas where research was concentrated) of urban-centric resilience research per period.

To further analyse the development of the (3) focus and (4) the conceptual underpinnings of urban-centric resilience research and establish general trends, the top ten most cited publications of each

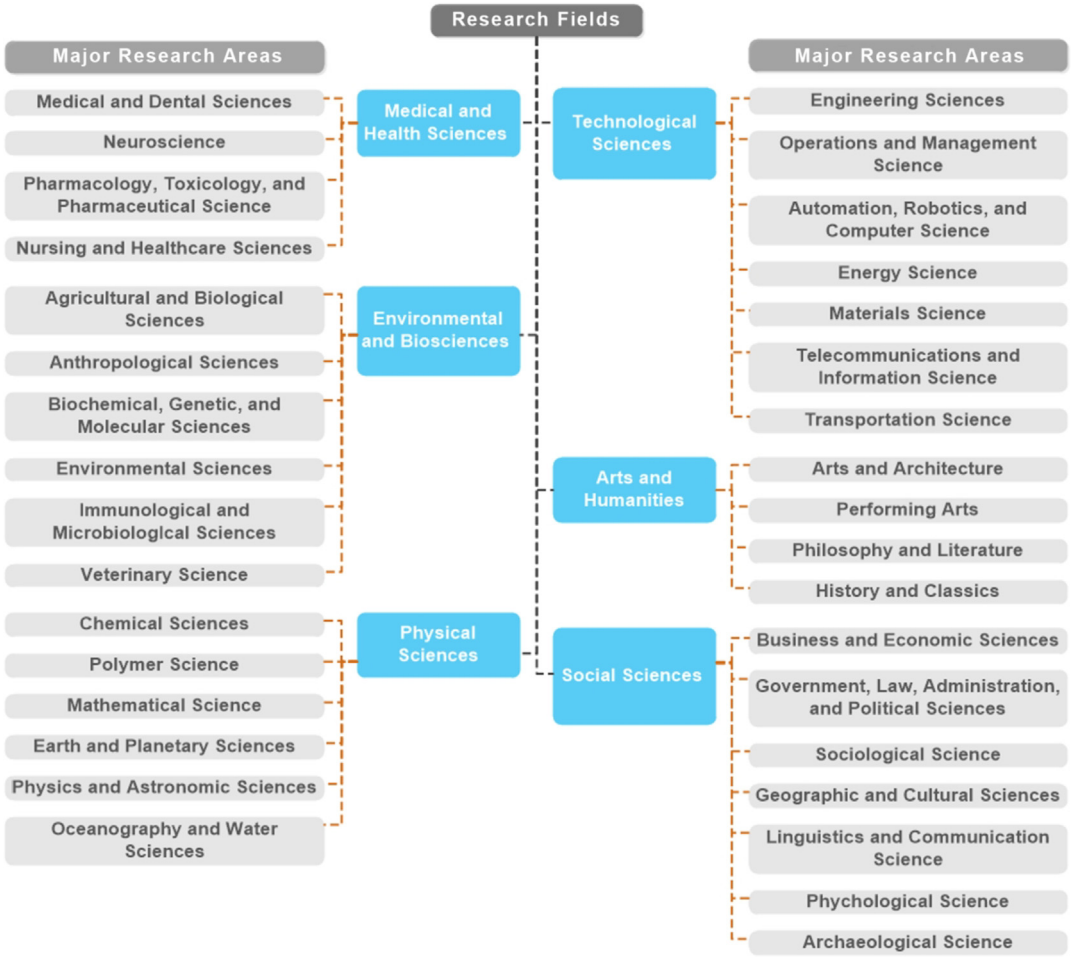



**Fig. 1.** The proposed systematisation of the six research fields, and respective major research areas (based on Thompson Reuters Web of Science, 2018).

period, per research field, were selected for a more thorough analysis. Each of these publications was then analysed to determine the '*focus*' (*scale* and *depth of the target system*), and conceptual underpinnings (which *conceptualisation of resilience* was the basis for the investigation) used in the application of the concept of '*resilience*' to the urban realm. As further explained bellow, the '*focus*' of research was determined based on whether the target publication focused on '*general resilience*' (resilience of any, and all parts of a system to all kinds of shocks), or on '*specified resilience*' (the resilience of a part of a system, and one or more identified shocks). The analysis of the results obtained allowed the determination of how the focus, and the conceptual underpinnings of urban-centric resilience research, evolved and changed throughout time, influencing the development of urban-centric resilience research.

## 3. Analysis of the evolution of '*urban-centric resilience*': results

Developing a more holistic review of urban-centric resilience means first and foremost understanding what the contemporary conceptualisation of '*urban environment*' means in scientific research. Hence, in recent urban-centric literature '*urban environments*' have tended (Davoudi, 2012; Hassler and Kohler, 2014b; Meerow et al., 2016) to be interpreted as either complex (Godschalk, 2003; Ruth and Coelho, 2007; Hammond et al., 2015), or complex adaptive systems (Alberti and Marzluff, 2004; Ernstson et al., 2010; Wu and Wu, 2013). Thus, Meerow et al. (2016, p. 45) have defined '*urban environments*' as "*complex, multi-scalar systems composed of socio-ecological and socio-technical networks that encompass governance, material and energy flows, infrastructure and form, and social-economic dynamics*". This perspective is also shared by other authors (Godschalk, 2003; Pickett et al., 2004; Fleischhauer, 2008), further suggesting cities are entities comprised of "*multi-scalar, networked, and often strongly coupled subcomponents*" (Meerow et al., 2016, p. 45).

Consequently, a more holistic understanding of the evolution of urban-centric resilience can only be achieved if, and when this broader conceptualisation of '*urban environment*' is taken into consideration. In other words, analysing the evolution of urban-centric resilience means considering the contribution of all research fields (Medical and Health Sciences, Environmental and Biosciences, Physical sciences, Technological Sciences, Arts and Humanities, and Social Sciences). Moreover, studying cities under the spectrum of complexity further implies perceiving distinctions between '*general*' and '*specified resilience*' (Walker and Salt, 2006; Lizarralde et al., 2015). Hence, while '*general resilience*' implies the '*resilience of any and all parts of a system to all kinds of shocks, including novel ones*' (Folke et al., 2010, p. 4), '*specified resilience*' (Carpenter et al., 2012, p. 3250) infers '*the resilience of a particular part of a system, related to a particular control variable, and one or more identified shocks*' (Folke et al., 2010, p. 4). Perceiving whether urban-centric resilience has been studied from the '*general*' or '*specified resilience*' standpoint means not only understanding the '*focus*' (*scale* and *depth*) and the '*complexity*' (from simpler to more complex systems) involved in this type of research, but also the conceptual underpinnings involved in less or more complex approaches to '*urban resilience*'.

In this context, this section contemplates the historical, thematic and conceptual analysis of urban-centric publications retrieved from the WSd, considering seven distinct five-year periods, which were demarcated from the dates of the first publications, up to the present time. This analysis emphasises how the concept of '*urban resilience*' evolved, bearing in mind how it was applied in distinct research fields, which

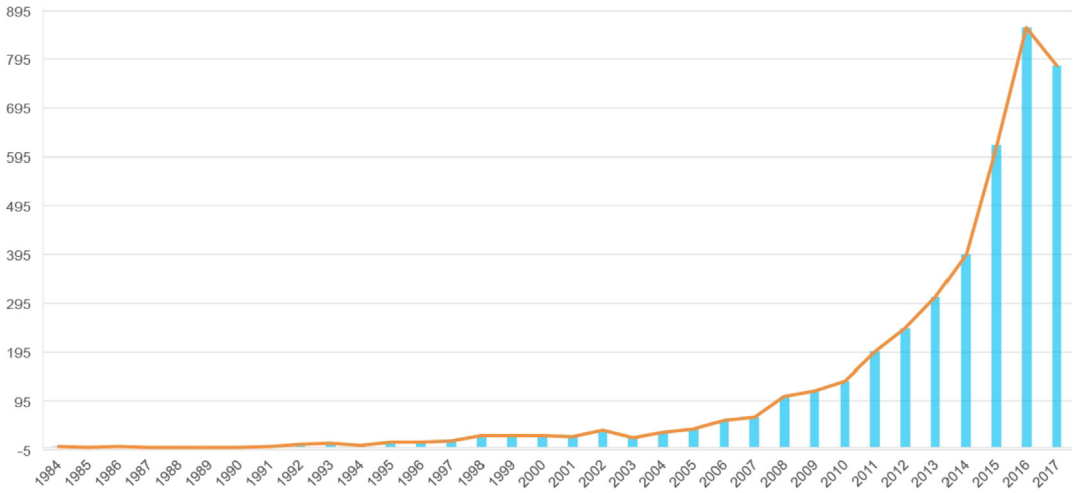



**Fig. 2.** Evolution of urban-centric resilience publications, per year, from 1984 to 2017. Numbers on the vertical axis correspond to the number of urban-centric resilience publications per year in the WSd. 6.

was the focus of such application ('*general*' or '*specified resilience*'), and which were the conceptual underpinnings behind it. To better understand development patterns, this analysis also contemplates the review of the number of publications released during each of the seven demarcated periods. Because the WSd classification system generally filed publications under more than one research field, there was the need to normalise the references retrieved from the WSd to a 100% baseline, to simplify the interpretation of the results.

### 3.1. 1984–1989 – Introduction of the concept in urban-centric science

Applications of resilience to the urban context can be traced back to the late 1980's. Bowonder and Chettri (1984) and Porter (1986) were among the first authors to use resilience in an urban-centric approach (2 publications - 0.05% of the total number of urban-centric resilience publications of the WSd – see Figs. 2 and 3). Their publications conceived '*urban resilience*' as the "*ability to withstand shock*" (Bowonder and Chettri, 1984, p. 285), emphasising a static resilience perspective which considered conditions near a steady state equilibrium (Davoudi, 2012, p. 300), which followed Holling's (1973) earlier conceptualisation of '***engineering resilience***' (*R1*). During this period the focus of urban-centric resilience research was on the Social Sciences (60.00% of all publications released in 1984–1988 – see Fig. 4). Resilience research focused on specific elements of the urban system, such as infrastructural (Bowonder and Chettri, 1984), social or economic urban components (Porter, 1986), emphasising the prevalence of the study of '*specified resilience*' (100.00% of all top ten period publications in the fields of Environmental and Biosciences, Physical Sciences, and Social Sciences).

### 3.2. 1989–1993 – Propagation of the application of the concept

Wyman and colleagues (Cowen et al., 1991; Wyman et al., 1991, 1993; Gribble et al., 1993) initiated the study of urban resilience in the context of family psychology and psychiatry, in the Social Sciences and Medical and Health Sciences. Ahmadi and colleagues (Chen and Ahmadi, 1992; Fan and Ahmadi, 1992; Su and Ahmadi, 1992) further developed an urban-centric resilience perspective for the study of seismic responses in the Technological Sciences. During this period, urban resilience research focused mostly on the Social Sciences (59.26% of all publications released in 1989–1993 – see Fig. 4), further expanding into the Medical and Health Sciences (29.63%) and the Technological Sciences (11.11%). This expansion led to an increase of the number of publications released between 1989 and 1993 (15 publications; 0.36% of the total number of urban-centric publications of the WSd – see Figs. 2 and 3).

During this period, the research emphasis was on the study of specific urban components ('*specified resilience*' - 100.00% of all top ten period publications in the fields of Medical and Health Sciences,

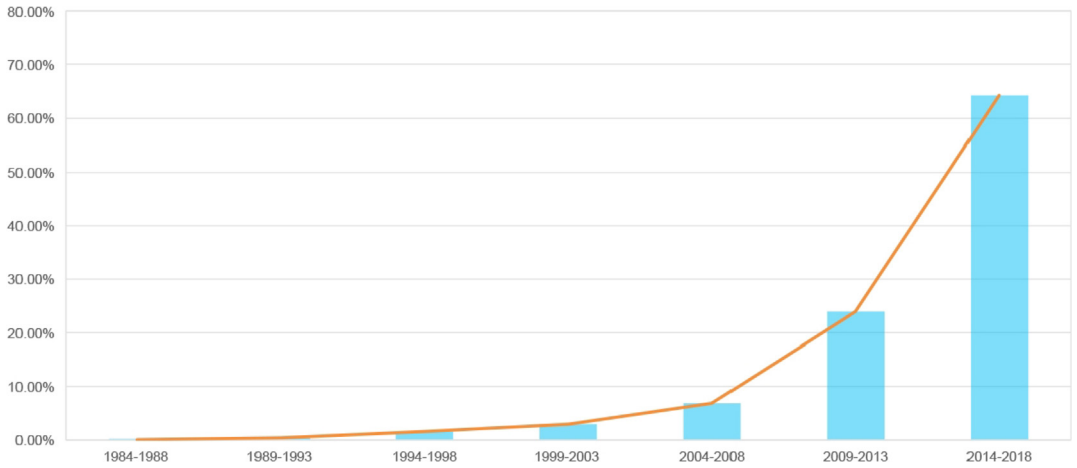
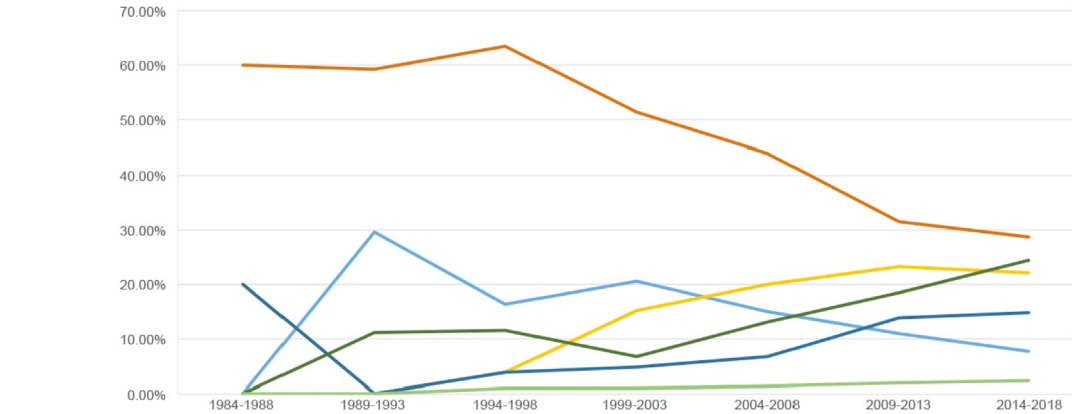



**Fig. 3.** Evolution of urban-centric resilience publications, per five-year period, from 1984 to 2018. Numbers on the vertical axis correspond to the percentage of urban-centric resilience publications per five-year period, over the total number of urban-centric resilience publications in the WSd.




| | 1984-1988 | 1989-1993 | 1994-1998 | 1999-2003 | 2004-2008 | 2009-2013 | 2014-2018 |
|---|---|---|---|---|---|---|---|
| Medical and Health Sciences | 0.00% | 29.63% | 16.35% | 20.59% | 14.97% | 11.01% | 7.74% |
| Environmental and Biosciences | 20.00% | 0.00% | 3.85% | 15.20% | 19.96% | 23.28% | 22.15% |
| Physical Sciences | 20.00% | 0.00% | 3.85% | 4.90% | 6.72% | 13.85% | 14.76% |
| Technological Sciences | 0.00% | 11.11% | 11.54% | 6.86% | 13.05% | 18.38% | 24.34% |
| Arts & Humanities | 0.00% | 0.00% | 0.96% | 0.98% | 1.34% | 2.02% | 2.34% |
| Social Sciences | 60.00% | 59.26% | 63.46% | 51.47% | 43.95% | 31.46% | 28.67% |

**Fig. 4.** Thematic evolution of urban-centric resilience publications, per five-year period, from 1984 to 2018, organised by research field. Numbers on the vertical axis correspond to the percentage of urban-centric resilience publications by research field, over the total number of urban-centric publications per five-year period, retrieved from the WSd.

Technological Sciences, and Social Sciences), such as structures and infrastructures (e.g., Chen and Ahmadi, 1992), educational milieus (e.g., Freiberg, 1993), families (e.g., Wyman et al., 1991), or individuals (e.g., Cowen et al., 1992). Though '*engineering conceptualisations*' (*R1*) prevailed during this period, the work of Luthar et al. (1993), and Spencer et al. (1993), who studied the concept in urban adolescents in the Social Sciences, emphasised resilience as "*adaptive coping*". This dynamic definition of resilience highlighted the '*ability to bounce forth*', emphasising the possibility of multiple equilibrium (Brand and Jax, 2007, p. 2), which had previously been characterised by Holling (1973) as '***ecological resilience***' (*R2*).

### 3.3. 1994–1998 – Expansion of the concept to all research fields

The research focus of urban resilience studies remained on the Social Sciences (63.46% of all publications released in 1994–1998 – see Fig. 4) between 1994 and 1998. The increasing study of resilience in water resources (e.g., Vogel et al., 1995), history (e.g. Murphy, 1998), sustainability (e.g. Berg and Nycander, 1997), planning (e.g. Wallace and Wallace, 1997), and psychiatry (e.g. Pfefferbaum and Pfefferbaum, 1998) led to an expansion of urban resilience research to all research fields (Medical and Health Sciences - 16.35%; Environmental and Biosciences - 3.85%; Physical Sciences - 3.85%; Technological Sciences - 11.53%; and Arts and Humanities - 0.96%).

The thematic expansion of resilience research led to a fourfold increase of the number of publications between 1994 and 1998 (65 publications - 1.56% of the total number of urban-centric publications of the WSd – see Figs. 2 and 3). Moreover, while '*engineering*' conceptualisations (*R1*) expanded into all research fields, '*ecological*' conceptualisations (*R2*) were further applied in the Medical and Health, Environmental, Physical and Technological Sciences (see e.g., Vogel et al., 1995; Cowen et al., 1996; Wallace and Wallace, 1997; Jarvela and Jormola, 1998). Although '*specified resilience*' remained the main research emphasis of urban-centric research (85.71% of all top ten period publications in all research fields), a movement towards the study of more complex systems and thus '*general resilience*' (14.29% of all top ten period publications in the fields of Environmental and Biosciences, Physical Sciences, Arts & Humanities, and Social Sciences) also began to emerge (see e.g., Berg and Nycander, 1997; Murphy, 1998; Wandersman and Nation, 1998).

### 3.4. 1999–2003 – Predominance of social and Psychic studies

Psychic studies (e.g., Luthar and Cicchetti, 2000), along with social work (e.g., Miller and MacIntosh, 1999) and medical and health research (e.g., North et al., 2002) emphasised the preponderance of the Social and Medical and Health Sciences during this period (88,89% of all publications released in 1999–2003 – see Fig. 4). The Environmental and Biosciences (15.20% of all publications released in 1999–2003) arose as another research focus, characterised by issues related to changing urban ecosystems and initial studies of resilient cities (see e.g., Douglass, 2000, 2002; Batty, 2001; Chocat et al., 2001; Godschalk, 2003). These focuses of research led to a twofold increase of the number of urban resilience publications between 1999 and 2003 (127 publications - 3.04% of the total number of urban-centric publications of the WSd – see Figs. 2 and 3).

The study of '*general resilience*' (18.18% of all top ten period publications in all research fields) was additionally highlighted in the Physical, Technological, and Social Sciences (see e.g., Batty and Xie, 1999; Batty, 2001; Godschalk, 2003). Klein et al. (2003), who addressed resilience in the context of natural hazards, further discussed a new conceptualisation of resilience, which targeted social-ecological systems in the context of urban-centric research. Their work emphasised '*urban resilience*' as the '*capacity of a system to respond, self-organise, and adapt to changing dynamics*', following what Holling and colleagues (Carpenter et al., 2001; Gunderson and Holling, 2001; Holling, 2001; Folke et al., 2002) had defined as '***social-ecological resilience***' (*R3*).

### 3.5. 2004–2008 – A new focus of interest in the Environmental Sciences and Ecology

Between 2004 and 2008, the main focus of interest shifted to the subfield of Environmental Sciences and Ecology (14.01% of all publications released in 2004–2008), in the Environmental and Biosciences (19.96% – see Fig. 4), with the study of resilience in the context of developing resilient cities (e.g., Pickett et al., 2004) and urban sustainability (e.g., Coaffee, 2008), or addressing climate change (e.g., Kovats and Akhtar, 2008). Psychology (10.56% of all publications released in 2004–2008) and Psychiatry (4.22%) remained important research subfields (see e.g., Li et al., 2007; Kidd and Shahar, 2008) in the Social (43.95%) and Medical and Health Sciences (14.97%). Other important focuses arose in Engineering (5.95% of all publications

released in 2004–2008), in the Technological Sciences (e.g., Fleischhauer, 2008), in Physical Geography (1.34%), Meteorology and Atmospheric Sciences (1.344%), and Geochemistry and Geophysics (1.34%), in the Physical Sciences (e.g., Colding, 2007), and in Architecture (0.96%), in the Arts and Humanities (e.g., Davis and Izadkhah, 2006).

The growth of interest in resilience research led to a twofold increase of the number of publications between 2004 and 2008 (290 publications – 6.94% of the total number of urban-centric publications of the WSd – see Figs. 2 and 3). In addition, the study of both '*general resilience*' (36.84% of all top ten period publications - see e.g., Pickett et al., 2004; Andersson, 2006; Campanella, 2006; Fleischhauer, 2008; Gleeson, 2008; Hess et al., 2008) and '*specified resilience*' (63.16% of all top ten period publications - see e.g., Comfort, 2006; Colding, 2007; Marshall and McGrath, 2007; Muller, 2007; Blackmore and Plant, 2008; Ebi and Semenza, 2008) continued to be developed simultaneously in all research fields. On the other hand, apart from the non-use of the concept of '*social-ecological resilience*' in Medical and Health Sciences, the use of all three conceptualisations of resilience (*R1*, *R2*, *R3*) expanded to all research fields.

### 3.6. 2009–2013 – A focus on the environment, engineering, and Urban Studies

The prominence of the Environmental Sciences and Ecology (18.98% of all publications released in 2009–2013), in the Environmental and Biosciences (23.38% – see Fig. 4), became more evident in urban resilience research during the 2009–2013 period. Even though the interest on social studies decreased, the Social Sciences remained the largest field of urban resilience research (31.46% of all publications released in 2009–2013). However, the focus of interest in the Social Sciences (6.98% of all publications released in 2009–2013) shifted to the subfield of Urban Studies (e.g., Desouza and Flanery, 2013; Jabareen, 2013; Lu and Stead, 2013). Engineering (7.69% of all publications released in 2004–2008) and Architecture (0.82%) respectively remained as the most important focuses of urban resilience research in the Technological Sciences (e.g., Ouyang et al., 2012) and the Arts and Humanities (e.g., Miller and Buys, 2012).

Other significant focus of urban resilience research arose in the subfields of Water Resources (4.69%), in the Physical Sciences (e.g., Wong and Brown, 2009), and Public, Environmental and Occupational Health (4.25%), in the Medical and Health Sciences (e.g., Okvat and Zautra, 2011). Overall, the growth of resilience research led to a threefold increase of the number of publications between 2009 and 2013 (1000 publications – 23.92% of the total number of urban-centric publications of the WSd – see Figs. 2 and 3). The simultaneous study of '*general´* (45.00% of all top ten period publications) and '*specified resilience*' (55.00% of all top ten period publications) continued to be a trend in all research fields. On the one hand, for the first time in the history of urban-centric resilience research, all three conceptualisations of resilience (*R1*, *R2*, *R3*) were applied to all research fields. On the other hand, a trend towards the use of dynamic conceptualisations of resilience (*R2*, *R3*) was highlighted in the Environmental and Biosciences (e.g., Ahern, 2011), Physical Sciences (e.g., Lovell and Taylor, 2013), Arts and Humanities (e.g., Pierdet, 2012), and in the Social Sciences (e.g., Wilkinson, 2012a).

### 3.7. 2014–2018 – Stabilisation of urban resilience trends

The focus of urban resilience research continued to be in the subfield of Environmental Sciences and Ecology (17.84% of all publications released in 2009–2013), in the Environmental and Biosciences (e.g., Meerow et al., 2016), between 2013 and 2018 (see Fig. 4). The Social Sciences remained as the largest field of urban resilience research (28.67% of all publications released in 2009–2013), with its main focus in Urban Studies (e.g., Martin and Sunley, 2015). Engineering (8.73% of all publications released in 2004–2008), Architecture (1.43%), Water Resources (4.68%), and Public, Environmental and Occupational Health (3.19%) respectively remained as the most important focuses of urban resilience research in the Technological Sciences (e.g., de Jong et al., 2015), in the Arts and Humanities (e.g., Feliciotti et al., 2016), in the Physical Sciences (e.g., Hammond et al., 2015), and in the Medical and Health Sciences (e.g., Malalgoda et al., 2016).

Overall, the growth of resilience research led to a threefold increase of the number of publications between 2014 and 2018 (2681 publications – 64.14% of the total number of urban-centric publications of the WSd – see Figs. 2 and 3). Alike the previous period, the simultaneous study of '*general´* (41.67% of all top ten period publications) and '*specified resilience*' (58.33% of all top ten period publications) continued to be a trend in all research fields. Moreover, the use of dynamic conceptualisations of resilience (*R2*, *R3*) was further highlighted in the Environmental and Biosciences (e.g., Andersson et al., 2014), Physical Sciences (e.g., Hammond et al., 2015), Arts and Humanities (e.g., Petrisor et al., 2016), and in the Social Sciences (e.g., Braun, 2014). Fig. 3 summarises the thematic evolution of urban-centric resilience.

### 3.8. 1984–2018 - Evolution of 'urban-centric resilience': summary table of results

In this subsection, the following Table 1 summarises the results of this research, by period, emphasising the evolution of the concept of resilience according to the number of publications, and thematic, research and conceptual focuses.

## 4. The advancement of '*urban resilience*': discussion

The results of the analysis presented in the previous section emphasised how the concept of '*urban resilience*' evolved, considering how it was applied in distinct research fields, which was the focus of such application ('*general*' or '*specified resilience*'), and which were the conceptual underpinnings behind it. This section discusses the implications of the results obtained earlier. Thus, the following three subsections concentrate on answering the research questions introduced at the beginning of this article.

### 4.1. Are there scientific evidences to support the favouring of urban resilience?

The concept of '*urban resilience*' has its roots in the broader conception of '*resilience*', which has evolved from the Technological Sciences (Tredgold, 1818; Merriman, 1885; Pimm, 1984; Hollnagel and Woods, 2006) and Environmental and Biosciences (Holling, 1973, 1996; Gunderson and Holling, 2001; Adger et al., 2011), to become a concept liberally and enthusiastically used by urban policy makers, practitioners and academics (Wilkinson et al., 2010; Porter and Davoudi, 2012; Benson and Craig, 2014; Meerow et al., 2016). In this context, we raised the question whether there were scientific evidences to support such the evolution of '*urban resilience*' evolved into a favoured concept in UDPM.

On the one hand, the bibliometric analysis of the evolution of urban-centric resilience indicates an expressive growth trend of the number of publications released. Of all urban-centric resilience publications of the WSd, 64.14% (2681 publications) were published between 2014 and 2018. On average, the number of publications has almost tripled (2,94 times ± SE = 0.428) every five years, since 1989. The annual average ( ± SE) of the number of urban-centric publications per every five-year period has also grown substantially from 5 ± 2.08 (1989–1993) to 536 ± 151.29 publications (2014–2018). These statistics testify that an increasing attention has been given to '*urban resilience*', accentuating a strong scientific expansion of its use, as previously emphasised, e.g., by Meerow et al. (2016) or by Hassler and Kohler (2014a, 2014b). These trends further underline that '*urban resilience*' is still a relatively

**Table 1**
Evolution of '*urban-centric resilience*': summary table of results.

| | Period | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1984–1988 | 1989–1993 | 1994–1998 | 1999–2003 | 2004–2008 | 2009–2013 | 2014–2018 |
| Evolution of publications | | | | | | | |
| Number of Publications[a] | 0.05% | 0.36% | 1.56% | 3.04% | 14.01% | 23.92% | 64.14% |
| Thematic Focus | | | | | | | |
| Main Research Field[b] | Social Sciences (60.00%) | Social Sciences (59.26%) | Social Sciences (63.46%) | Social Sciences (51.47%) | Social Sciences (43.95%) | Social Sciences (31.46%) | Social Sciences (28.67%) |
| Main Research Subfield[b] | Social Sciences (other topics) (40.00%) | Psychology (29.63%) | Psychology (23.08%) | Psychology (25.49%) | Environmental Sciences and Ecology (14.01%) | Environmental Sciences and Ecology (18.98%) | Environmental Sciences and Ecology (17.84%) |
| Research Focus | | | | | | | |
| General Resilience[c] | 0.00% | 0.00% | 14.29% | 18.18% | 36.84% | 45.00% | 41.67% |
| Specified Resilience[c] | 100.00% | 100.00% | 85.71% | 81.82% | 63.16% | 55.00% | 58.33% |
| Conceptual Focus | | | | | | | |
| Engineering Resilience[d] | Environmental and Biosciences, Physical, and Social Sciences | Medical and Health, Technological, and Social Sciences | All Research Fields | All Research Fields | All Research Fields | All Research Fields | All Research Fields |
| Ecological Resilience[d] | – | Social Sciences | All Research Fields apart from Arts and Humanities | All Research Fields | All Research Fields | All Research Fields | All Research Fields |
| Social-ecological Resilience[d] | – | – | – | Environmental and Biosciences, and Technological Sciences | All Research Fields apart from Medical and Health Sciences | All Research Fields | All Research Fields |

[a] Percentage of the number of period publications over the total number of resilience publications of the WSd.
[b] Percentage of the number of field or subfield publications over the total number of resilience publications released during the period.
[c] Percentage of the number of research focus publications over the total number of resilience publications released during the period.
[d] Research Fields of application of the concept.

'new' (Wilkinson et al., 2010; Shaw, 2012), especially when compared to the broader study of resilience, which originated in the 1800s (Tredgold, 1818; Mallet, 1856, 1862; Rankine, 1862).

On the other hand, the scientific expansion of the use of the concept to all research fields can highlight the predisposition of the concept to become a transdisciplinary conceptualisation, with recognisable conceptual underpinnings. The thematic expansion characterised here subsidises that scientific knowledge on '*urban resilience*' has significantly grown to point where it can support not only theoretical (Hassler and Kohler, 2014a, 2014b; Meerow et al., 2016), but also practical applications (Asprone et al., 2013; Childers et al., 2015) of the concept in UDPM. Previous discussions have underlined the role of resilience as an '*integrative metaphor*' or as a '*boundary object*' (Brand and Jax, 2007; Béné et al., 2014; Meerow et al., 2016), which is malleable and can be successfully adapted by diverse stakeholders (Brand and Jax, 2007, p. 1). Hence, while urban resilience has been gaining scientific prominence (Davoudi, 2012; Béné et al., 2014; Cartalis, 2014; Hassler and Kohler, 2014a) it has also been used to overcome field-related and theory-practice-related boundaries (Béné et al., 2014; Hassler and Kohler, 2014a, 2014b; Meerow et al., 2016).

### 4.2. Has there been a thematic expansion of the use of urban resilience?

While the evolution of '*resilience*' has been reviewed throughout the distinct research fields (e.g., Brand, 2005, 2009; Mcaslan, 2010; Martin-Breen and Anderies, 2011), the evolution of '*urban-centric resilience*' has been somewhat limited to specific research branches (Hassler and Kohler, 2014a; Meerow et al., 2016), and circumscribed to specific clusters of knowledge (e.g., Cruz et al., 2013; e.g., Meerow and Newell, 2015). In this context, the approach followed in this research has provided a broader spectrum of analysis, which allowed us to understand how all research fields have contributed to the development of the concept of '*urban resilience*'.

The results of the bibliometric analysis performed showed that urban-centric resilience was first contemplated in the Physical, Social, and Environmental and Biosciences, under the form of '*specified resilience*'. Between 1989 and 1993 the use of the concept expanded into the Medical and Health and the Technological Sciences. By the end of 1998, the application of '*urban resilience*' had expanded to all research fields. While the Social Sciences have remained the stronghold of urban-centric resilience research throughout time, between 2004 and 2008 the focus of interest shifted to the subfield of Environmental Sciences and Ecology.

As '*urban resilience*' studies progressively focused on more '*complex*' and '*adaptive systems*', the Environmental and Biosciences and Urban Studies emerged as the main subfields of urban-centric resilience research. Consequently, the emphasis of urban-centric resilience research in the Environmental Sciences and Ecology (Pickett et al., 2004; Ernstson et al., 2010; Childers et al., 2014), or in Urban Studies (Ruth and Coelho, 2007; Jabareen, 2013; Braun, 2014), has contributed to a more integrated perspective of the role of '*resilience*' in sustaining urban-centric social-ecological systems (Folke, 2006; Wilkinson, 2012b; Yamagata and Maruyama, 2016).

### 4.3. Has urban resilience evolved conceptually until theoretical stabilisation?

Resilience has been mainly defined as a system's '*speed of return to equilibrium after perturbation*' (engineering resilience - R1 - Pimm, 1984, pp. 321–326), '*magnitude of absorbed disturbance, before its structure changes*' (ecological resilience - R2 - Holling, 1996, p. 33, p. 33), or '*ability to change, adapt, and transform in response to disturbances*' (Davoudi, 2012, p. 302). Furthermore, urban-centric resilience research has also focused on '*general*' ('*resilience of all parts of a system to all kinds of shocks*'), and '*specified resilience*' ('*resilience of a part of a system, related one or more identified shocks*'). However, although these conceptualisations have often been interpreted in urban-centric research (Cruz et al., 2013; Hassler and Kohler, 2014a; Meerow et al., 2016), few attempts have been made to understand how they have influenced the development of '*urban resilience*'.

The evolution of '*urban resilience*' characterised in this research can be interpreted not only as a thematic expansion, but also as a thematic evolution towards integration (e.g., the study of social-ecological systems, as coupled systems of humans and nature), complexity (e.g., the systemic study of cities and their subcomponents), and adaptation (e.g., the study of increasingly more adaptive systems). Thus, on the one hand, this research has highlighted that in addition to the study of '*specified resilience*', a movement towards the study of '*general resilience*' emerged between 1994 and 1998. Thus, urban-centric resilience research has since then concentrated on both '*specified*' and '*general resilience*', emphasising Walker and Salt's (2006, p. 121) perspective on the importance of maintaining '*general resilience*' in addition to '*specified resilience*'.

On the other hand, our research has also emphasised that although '*engineering resilience*' was first introduced into urban-centric research, and followed by '*ecological*' (*R2*), and '*social-ecological resilience*' (*R3*), all three resilience conceptualisations coexist in contemporary urban-centric resilience research. The fact that these conceptualisations co-exist and are further applied in all research fields suggests that their use does not exclude each other but is rather mutually reinforcing. The interesting aspect of this is that '*urban resilience*' emerges as the result not of one but all three definitions, each of them leading to different outcomes: persistence (*R1*), incremental adjustment (*R2*) or transformational modification (*R3*), as emphasised by Béné et al. (2014).

Moreover, as emphasised by Meerow et al. (2016), we have identified the formation of a trend towards the use of '*dynamic conceptualisations*' of resilience (R2, R3). This dynamic emphasis of urban-centric resilience research is also aligned with the opinion of Lizarralde et al. (2015, p. 98), who recently suggested that '*social-ecological resilience*' (R3) is the formulation that better addresses the inclusive perspective of integrating distinct: (a) levels of analysis and intervention; (b) time-scales; (c) intervention sectors; and (d) intervention types and units of analysis. Consequently, this analysis suggests that '*urban resilience*' is trending towards its theoretical stabilisation, one in which '*social-ecological resilience*' (R3) can be understood as the most integrative and relevant resilience conceptualisation to UDPM.

However, there is an effective danger that those who study and research resilience, do it departing from distinct conceptual underpinnings (*R1*, *R2*, or *R3*), thus blurring the result of their intents, while creating undesirable theoretical confusion. For example, only about 10.00% of all urban-centric resilience research in the WSd clearly emphasised its basis resilience conceptualisation (*R1*, *R2*, or *R3*) in the *Topic* (*title*, *abstract*, or *keywords*). To avoid theoretical traps, there is an obvious need for scientists studying '*urban resilience*' to be clear about the conceptualisation from which they depart. Nevertheless, if these theoretical traps are avoided, '*urban resilience*' can remain an '*integrative metaphor*', which is malleable and can be successfully adapted by diverse stakeholders. Additionally, avoiding the formerly mentioned traps thus reinforces '*urban resilience*' as a systemic, integrative, and incremental UDPM concept.

## 5. Conclusions

In this research, we have focused on reviewing the evolution of resilience and discussing its application in Urban Development, Planning and Management (UDPM). This review has concentrated on the analysing how (1) 'urban resilience' has evolved into a favoured concept in UDPM, (2) the different research fields have contributed to such evolution, and (3) 'urban resilience' has evolved conceptually to its potential theoretical stabilisation.

The bibliometric analysis of the evolution of urban-centric resilience indicates that an increasing attention has been given to '*urban*

*resilience*', accentuating a strong scientific expansion of its use. The concept has now been widely applied by urban academics, practitioners, and policy makers. This investigation suggests that urban-centric resilience was first contemplated in the Physical, Social, and Environmental and Biosciences, under the form of '*specified resilience*', progressively expanding to all research fields, and to the study of '*general resilience*'. As '*urban resilience*' studies progressively focused on more '*complex*' and '*adaptive systems*', the Environmental and Biosciences and Urban Studies emerged as the main subfields of urban resilience research.

Consequently, this research emphasises that '*resilience*' has visibly grown in importance within contemporary UDPM. Thus, the thematic evolution of '*urban resilience*' described in this investigation can be interpreted as a progressive development towards more integrative, complex, and adaptive approaches, which emphasise the role of '*resilience*' in developing and sustaining urban-centric social-ecological systems. Furthermore, the expansion of the use of the concept to all research fields can further highlight its predisposition to become an '*integrative metaphor*', which is malleable and can be successfully adapted by diverse stakeholders, overcoming field-related and theory-practice-related boundaries.

Moreover, resilience has been mainly defined as '*engineering*' (*R1*), '*ecological*' (*R2*), or '*social-ecological resilience*' (*R3*), and has been further studied from the perspective of '*general*' and '*specified resilience*'. In this context, this research has emphasised a trend towards the theoretical stabilisation of the concept of '*urban resilience*' and its underlying theoretical assumptions. First, urban-centric resilience research has trended towards the simultaneous study of '*specified*' and '*general resilience*', progressively concentrating on more complex urban systems. Second, the simultaneous use of '*engineering*' (*R1*), '*ecological*' (*R2*), or '*social-ecological resilience*' (*R3*) conceptualisations has proliferated throughout all research fields during recent years. Third, there has been a favouring of the use of '*dynamic conceptualisations*' of resilience (*R2*, *R3*) in urban-centric research, which reemphasise a trend towards integration, complexity, and adaptation. Fourth, urban resilience research would be better served by the application of its most integrative conceptualisation – '*social-ecological resilience*' (*R3*).

However, there are still some grey areas when it comes to study of '*urban resilience*'. On the one hand, the fact resilience conceptualisations coexist and are further applied in all research fields suggests that their use does not exclude each other but is rather mutually reinforcing. On the other hand, their coexistence can create theoretical confusion, especially when scientists do not clearly define which resilience conceptualisation (*R1*, *R2*, or *R3*) is being used in their studies. Consequently, further research is needed to fully understand the conceptual underpinnings of these conceptualisations (*R1*, *R2*, or *R3*) in the distinct research fields, and whether '*social-ecological resilience*' is in fact the conceptualisation that better serves the application of Resilience Theory to UDPM.

Finally, the results of this investigation imply that the concept of '*urban resilience*' can only avoid the danger of falling into oblivion, given its inherent theoretical intricacy, if those who study, and research resilience depart from a clear conceptual basis. Thus, if conceptual traps are effectively avoided, then '*urban resilience*' can reemphasise its role as an '*integrative metaphor*' in UDPM, which is malleable and can be successfully adapted by diverse stakeholders. In this context, *social-ecological resilience*' (R3), as the most integrative resilience conceptualisation, might just be the formulation that better overcomes field-related and theory-practice-related boundaries, in the development of a sustained and coherent UDPM perspective.

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